Environ Int. 2013 Jan;51:116-40. doi: 10.1016/j.envint.2012.10.009. Epub 2012 Dec 20.

A review of the ecological effects of radiofrequency electromagnetic fields (RF-EMF).

Cucurachi S[1], Tamis WL, Vijver MG, Peijnenburg WJ, Bolte JF, de Snoo GR.

Author information

Abstract

OBJECTIVE: This article presents a systematic review of published scientific studies on the potential **ecological** effects of radiofrequency electromagnetic fields (RF-**EMF**) in the range of 10 MHz to 3.6 GHz (from amplitude modulation, AM, to lower band microwave, MW, **EMF**).

METHODS: Publications in English were searched in ISI Web of Knowledge and Scholar Google with no restriction on publication date. Five species groups were identified: birds, insects, other vertebrates, other organisms, and plants. Not only clear **ecological** articles, such as field studies, were taken into consideration, but also biological articles on laboratory studies investigating the effects of RF-**EMF** with biological endpoints such as fertility, reproduction, behaviour and development, which have a clear **ecological** significance, were also included.

RESULTS: Information was collected from 113 studies from original peer-reviewed publications or from relevant existing reviews. A limited amount of **ecological** field studies was identified. The majority of the studies were conducted in a laboratory setting on birds (embryos or eggs), small rodents and plants. In 65% of the studies, **ecological** effects of RF-**EMF** (50% of the animal studies and about 75% of the plant studies) were found both at high as well as at low dosages. No clear dose-effect relationship could be discerned. Studies finding an effect applied higher durations of exposure and focused more on the GSM frequency ranges.

CONCLUSIONS: In about two third of the reviewed studies **ecological** effects of RF-**EMF** was reported at high as well as at low dosages. The very low dosages are compatible with real field situations, and could be found under environmental conditions. However, a lack of standardisation and a limited number of observations limit the possibility of generalising results from an organism to an ecosystem level. We propose in future studies to conduct more repetitions of observations and explicitly use the available standards for reporting RF-**EMF** relevant physical parameters in both laboratory and field studies.

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Electrosmog and species conservation

Alfonso Balmori

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HIGHLIGHTS

- Studies have shown effects in both animals and plants.
- Two thirds of the studies reported ecological effects.
- There is little research in this area and further research is needed.
- The technology must be safe.
- Controls should be introduced to mitigate the possible effects.

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ABSTRACT

Despite the widespread use of wireless telephone networks around the world, authorities and researchers have paid little attention to the potential harmful effects of mobile phone radiation on wildlife. This paper briefly reviews the available scientific information on this topic and recommends further studies and specific lines of research to confirm or refute the experimental results to date. Controls must be introduced and technology rendered safe for the environment, particularly, threatened species.

1. Introduction

Since the introduction of wireless telecommunication in the 1990s, the roll-out of mobile phone networks has led to a massive increase in environmental exposure to electromagnetic radiation (Levitt and Lai, 2010). The existing standards of public health protection only consider the effects of short-term thermal exposure; however, biological effects resulting from electromagnetic radiation might depend on dosage, including long-term chronic effects, and there is considerable experimental evidence for non-thermal biological effects (Hyland, 2000).

Researchers have also paid little attention to the potential harmful effects of microwaves from mobile phone mast radiation on wildlife. In about two thirds of the reviewed studies ecological effects of RF-EMF were reported, at high as well as at low dosages, linking the hazards with different modes and extents of exposure (Cucurachi et al., 2013). Although the species conservation implications are unclear, current evidence indicates that chronic exposure to electromagnetic radiation, at levels that are found in the environment, may particularly affect the immune, nervous, cardiovascular and reproductive systems (Balmori, 2009). Animals exposed to radiation emissions from nearby antennas may suffer changes in the enzyme activities that disappear when they are moved away from the source (Hässig et al., 2014), and underlying plausible explanations at the cellular level have been proposed in the findings (Pall, 2013).

There are now calls for action from government agencies, both in the U.S. and Europe. In the U.S. the Director of the Office of Environmental Policy and Compliance of the United States Department of the Interior sent a letter (Feb, 2014) to the National Telecommunications and Information Administration in the Department of Commerce which addressed the Interior Department's concern about the negative impact of cell tower radiation on the health of migratory birds and other wildlife. The Interior Department accused the Federal government of employing outdated radiation standards set by the Federal Communications Commission (FCC) (United States Department of the Interior, 2014). The European Environment Agency states: «Independent research into the many unknowns about the biological and ecological effects of RF are urgently needed, given the global exposure of over 5 billion people and many other species, especially those, like bees and some birds whose navigation systems are possibly being affected

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Short communication

Anthropogenic radiofrequency electromagnetic fields as an emerging threat to wildlife orientation

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HIGHLIGHTS

- The growth of wireless telecommunication technologies causes increased electrosmog.
- Radio frequency fields in the MHz range disrupt insect and bird orientation.
- Radio frequency noise interferes with the primary process of magnetoreception.
- Existing guidelines do not adequately protect wildlife.
- Further research in this area is urgent.

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Magnetic compass
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Orientation

ABSTRACT

The rate of scientific activity regarding the effects of anthropogenic electromagnetic radiation in the radiofrequency (RF) range on animals and plants has been small despite the fact that this topic is relevant to the fields of experimental biology, ecology and conservation due to its remarkable expansion over the past 20 years. Current evidence indicates that exposure at levels that are found in the environment (in urban areas and near base stations) may particularly alter the receptor organs to orient in the magnetic field of the earth. These results could have important implications for migratory birds and insects, especially in urban areas, but could also apply to birds and insects in natural and protected areas where there are powerful base station emitters of radiofrequencies. Therefore, more research on the effects of electromagnetic radiation in nature is needed to investigate this emerging threat.

Different animal groups are sensitive to low frequency electromagnetic fields, and many species with receptor organs are provided with important orientation cues from natural electric fields (Kalmijn, 1988). Animals can use the direction of the magnetic field as a compass and the intensity of the magnetic field as a component of the navigational map, with light-dependent reactions in specialised photo-pigments and reactions involving small crystals of magnetite, using one of these systems, or both simultaneously, depending on the animal groups (Kirschvink et al., 2001; Johnsen and Lohmann, 2005; Wiltschko et al., 2007; Hsu et al., 2007; Ritz et al., 2009; Wajnberg et al., 2010).

Some insects, like bumblebees (*Bombus terrestris*), can interact with floral electric fields and electric field sensing constitutes a potentially important sensory modality. The perception of weak electric fields by bees in nature, which should be considered alongside vision and olfaction, may have an adaptive value (Clarke et al., 2013). An applied static magnetic field affects circadian rhythms, magnetosensitivity and orientation of insects through cryptochromes, and a prolonged weakening of the geomagnetic field affects the immune system of rats (Roman and Tombarkiewicz, 2009; Yoshii et al., 2009).

In the radiofrequency range, the rapid development and increased use of wireless telecommunication technologies led to a substantial change in the radio-frequency electromagnetic field (RF-EMF) exposure (Levitt and Lai, 2010). This increased exposure was most consistently observed in outdoor areas due to emissions from radio and mobile phone base stations (Urbinello et al., 2014). Current evidence indicates that exposure at levels found in the environment (in urban areas and near base stations), may particularly alter the receptor organs to orient in the magnetic field of the earth, although the species conservation implications are unknown. Radio frequency fields in the MHz range disrupt birds' orientation interfering directly with the primary processes of magnetoreception and therefore disable the avian compass as long as

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Mobile phone mast effects on common frog (Rana temporaria) tadpoles: the city turned into a laboratory.

(PMID:20560769)

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Electromagnetic Biology and Medicine [2010, 29(1-2):31-35]

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DOI: 10.3109/15368371003685363

Abstract

An experiment has been made exposing eggs and tadpoles of the common frog (Rana temporaria) to electromagnetic radiation from several mobile (cell) phone antennae located at a distance of 140 meters. The experiment lasted two months, from the egg phase until an advanced phase of tadpole prior to metamorphosis. Measurements of electric field intensity (radiofrequencies and microwaves) in V/m obtained with three different devices were 1.8 to 3.5 V/m. In the exposed group (n = 70), low coordination of movements, an asynchronous growth, resulting in both big and small tadpoles, and a high mortality (90%) was observed. Regarding the control group (n = 70) under the same conditions but inside a Faraday cage, the coordination of movements was normal, the development was synchronous, and a mortality of 4.2% was obtained. These results indicate that radiation emitted by phone masts in a real situation may affect the development and may cause an increase in mortality of exposed tadpoles. This research may have huge implications for the natural world, which is now exposed to high microwave radiation levels from a multitude of phone masts.

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Original article

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Mobile phone-induced honeybee worker piping

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Received 24 June 2009 – Revised 29 March 2010 – Accepted 8 April 2010

Abstract – The worldwide maintenance of the honeybee has major ecological, economic, and political implications. In the present study, electromagnetic waves originating from mobile phones were tested for potential effects on honeybee behavior. Mobile phone handsets were placed in the close vicinity of honeybees. The sound made by the bees was recorded and analyzed. The audiograms and spectrograms revealed that active mobile phone handsets have a dramatic impact on the behavior of the bees, namely by inducing the worker piping signal. In natural conditions, worker piping either announces the swarming process of the bee colony or is a signal of a disturbed bee colony.

worker bee / acoustic communication / mobile phone handset / worker piping / induction

1. INTRODUCTION

Honeybees are essential partners for the success of agriculture. The economical role of honeybees in worldwide pollination has been valued to be around 153 billion euros in the year 2005 (Gallai et al. 2009). Bee losses have been recorded for more than a century (Hart 1893; Aikin 1897; Beuhne 1910; Wilson and Menapace 1979). Scientists suspect many factors to be responsible for the killing of the bees, of which the varroa mite, pesticides, viruses, farming practices, monoculture, hygiene in the hive, and climatic factors are the most widely cited possibilities. Starting in 2003–2004, bee colonies worldwide suddenly began to show symptoms of the so-called colony collapse disorder (CCD). CCD initially affects the worker bees, which desert the hive. The queen bee is usually abandoned in the hive with the young brood and with an abundance of honey, so that the colony can survive for a very short time. However, without the worker bee population, the colony becomes unsustainable and dies out. Never before have honeybees disappeared globally and at such a high rate.

Current theories about the potential cause(s) of CCD essentially include increased losses due to the invasive varroa mite (Donzé et al. 1998). Pesticide poisoning (through exposure to pesticides applied for crop pest control), potential immune-suppressing stress on bees (caused by one or a combination of several factors such as apiary overcrowding, pollination of crops with low nutritional value, pollen or nectar dearth), drought, monocultural practices, migratory stress (brought about by the moving of the bees in long distances), and increased transmission of pathogens have also been usually cited as a cause of CCD (U.S.D.A. 2007). Other causes might include genetically modified crops (Malone and Pham-Delegue 2001) and exceptionally cold winters.

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Exposure to cell phone radiations produces biochemical changes in worker honey bees

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Abstract

Go to:

The present study was carried out to find the effect of cell phone radiations on various biomolecules in the adult workers of *Apis mellifera* L. The results of the treated adults were analyzed and compared with the control. Radiation from the cell phone influences honey bees' behavior and physiology. There was reduced motor activity of the worker bees on the comb initially, followed by en masse migration and movement toward "talk mode" cell phone. The initial quiet period was characterized by rise in concentration of biomolecules including proteins, carbohydrates and lipids, perhaps due to stimulation of body mechanism to fight the stressful condition created by the radiations. At later stages of exposure, there was a slight decline in the concentration of biomolecules probably because the body had adapted to the stimulus.

Keywords: *Apis mellifera*, biomolecules, cell phone radiations, hemolymph

INTRODUCTION

Go to:

Cell phone usage is a major public health concern because of potential risk of chronic exposure to low level of radiofrequency and microwave radiation that pulse off the phone antennae in close proximity to the head.[1] These concerns have induced a large body of research, both epidemiological and experimental, in humans and animals. Honeybees are reliable indicators of environmental status and possess several important ecological, ethological, and morphological characteristics. They are the best experimental animals to study the effect of electromagnetic waves because they possess in their abdomen magnetite granules which help the bees in their orientation flight. Moreover, the integument of bees has semiconductor functions. It is in the light of these characteristics of honey bees that the present investigation was planned to study the metabolic changes with respect to proteins, carbohydrates, and lipids in hemolymph of worker honeybee of *Apis mellifera* L. exposed to cell phone radiation.

MATERIALS AND METHODS

Go to:

Study area

Changes in honeybee behaviour and biology under the influence of cellphone radiations

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Increase in the usage of electronic gadgets has led to electropollution of the environment. Honeybee behaviour and biology has been affected by electrosmog since these insects have magnetite in their bodies which helps them in navigation. There are reports of sudden disappearance of bee populations from honeybee colonies. The reason is still not clear. We have compared the performance of honeybees in cellphone radiation exposed and unexposed colonies. A significant ($p < 0.05$) decline in colony strength and in the egg laying rate of the queen was observed. The behaviour of exposed foragers was negatively influenced by the exposure, there was neither honey nor pollen in the colony at the end of the experiment.

Keywords: Colony strength, electromagnetic field, foraging behaviour, honeybees.

RECENTLY a new phenomenon of sudden disappearance of bees with little sign of disease or infection has been reported from the world over. Bees simply leave the hives and fail to return[1,2]. Colony collapse disorder (CCD) is the name given to this problem. Bee colony collapse was previously attributed to viruses, parasitic mites, pesticides, genetically modified crop use and climate change. On the basis of widely reported influences on honeybee behaviour and physiology, electromagnetic field is emerging as a potent culprit[3].

The decimation of bees is seen as a grave risk to the delicate equilibrium of the ecosystem. There is an urgent need to understand the complicity of interaction involved in the influence of electromagnetic radiations particularly due to cellphones on honeybee biology and to work out a strategy of development with minimal environmental implications.

Four colonies of honeybees, *Apis mellifera* L, were selected in the apiary of the Zoology Department, Panjab University, Chandigarh. Two colonies T_1 and T_2 were marked as test colonies. These were provided with two functional cellphones of GSM 900 MHz frequency. The average radiofrequency (RF) power density was 8.549 $\mu W/cm^2$ (56.8 V/m, electric field). The cellphones were placed on the two side walls of the bee hive in call mode. Electromotive field (EMF) power density was measured with the help of RF power density meter (Figure 1). Blank colony (B) was equipped with dummy cellphones, while the control colony (C) had no cellphones.

The exposure given was 15 min, twice a day during the period of peak bee activity (1100 and 1500 h). The experiment was performed twice a week extending over February to April and covering two brood cycles.

The following biological aspects were recorded during observations.

Brood area: The total area under brood comprising eggs, larvae and sealed brood was measured in all the experimental colonies with the help of a 1 sq. cm grid mounted on a comb frame[4].

Queen prolificacy: This was measured in terms of egg laying rate of the queen. In order to determine the number of eggs laid by the queen per day, the total brood area measured was multiplied by a factor of 4 to calculate the total number of cells containing the brood (there are 4 cells per sq. cm of comb). This number was divided by 21 (as the average time taken for an egg to change into an adult worker is 21 days) to get the egg laying rate of the queen[5].

The queen prolificacy was calculated as:

$$\mathrm{QP} = \frac{\text{Total brood area (cm}^2) \times 4}{21}.$$

The following behavioural aspects were observed.

Foraging: (i) Flight activity measured as number of worker bees leaving the hive entrance per minute: before exposure and during exposure. (ii) Pollen foraging efficiency measured as number of worker bees returning with pollen loads per minute: before exposure and during exposure. (iii) Returning ability determined by counting the

Figure 1. Experimental colony showing placement of mobile phones and power density meter.

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***NATURE* | LETTER**

日本語要約

Anthropogenic electromagnetic noise disrupts magnetic compass orientation in a migratory bird

Svenja Engels, Nils-Lasse Schneider, Nele Lefeldt, Christine Maira Hein, Manuela Zapka, Andreas Michalik, Dana Elbers, Achim Kittel, P. J. Hore & Henrik Mouritsen

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Electromagnetic noise is emitted everywhere humans use electronic devices. For decades, it has been hotly debated whether man-made electric and magnetic fields affect biological processes, including human health[1, 2, 3, 4, 5]. So far, no putative effect of anthropogenic electromagnetic noise at intensities below the guidelines adopted by the World Health Organization[1, 2] has withstood the test of independent replication under truly blinded experimental conditions. No effect has therefore been widely accepted as scientifically proven[1, 2, 3, 4, 5, 6]. Here we show that migratory birds are unable to use their magnetic compass in the presence of urban electromagnetic noise. When European robins, *Erithacus rubecula*, were exposed to the background electromagnetic noise present in unscreened wooden huts at the University of Oldenburg campus, they could not orient using their magnetic compass. Their magnetic orientation capabilities reappeared in electrically grounded, aluminium-screened huts, which attenuated electromagnetic noise in the frequency range from 50 kHz to 5 MHz by approximately two orders of magnitude. When the grounding was removed or when broadband electromagnetic noise was deliberately generated inside the screened and grounded huts, the birds again lost their magnetic orientation capabilities. The disruptive effect of radiofrequency electromagnetic fields is not confined to a narrow frequency band and birds tested far from sources of electromagnetic noise required no screening to orient with their magnetic compass. These fully double-blinded tests document a reproducible effect of anthropogenic electromagnetic noise on the behaviour of an intact vertebrate.

Subject terms: Animal behaviour Risk factors Biological physics

Article | OPEN

A magnetic compass aids monarch butterfly migration

Patrick A Guerra, Robert J Gegear & Steven M Reppert

Nature Communications **5**, Article number: 4164 (2014)
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Animal migration Animal physiology

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Abstract

Convincing evidence that migrant monarch butterflies (*Danaus plexippus*) use a magnetic compass to aid their fall migration has been lacking from the spectacular navigational capabilities of this species. Here we use flight simulator studies to show that migrants indeed possess an inclination magnetic compass to help direct their flight equatorward in the fall. The use of this inclination compass is light-dependent utilizing ultraviolet-A/blue light between 380 and 420 nm. Notably, the significance of light <420 nm for inclination compass function was not considered in previous monarch studies. The antennae are important for the inclination compass because they appear to contain light-sensitive magnetosensors. For migratory monarchs, the inclination compass may serve as an important orientation mechanism when directional daylight cues are unavailable and may also augment time-compensated sun compass orientation for appropriate directionality throughout the migration.

Introduction

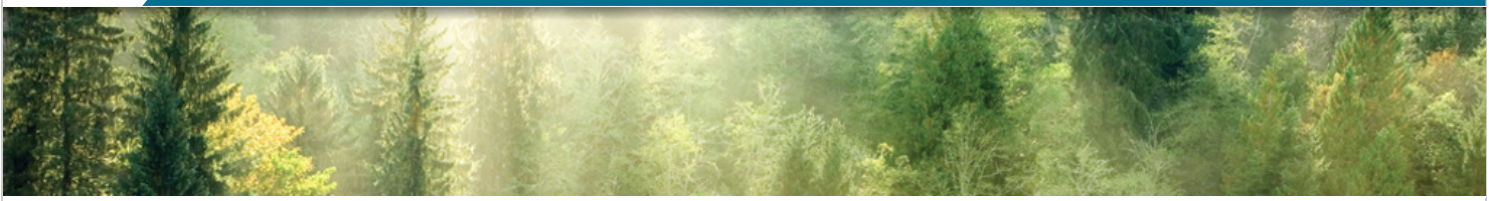
Radiofrequency radiation injures trees around mobile phone base stations

Article *in* Science of The Total Environment 572:554-569 · August 2016 *with* 1,124 Reads
DOI: 10.1016/j.scitotenv.2016.08.045

1st Cornelia Waldmann-Selsam
2nd Alfonso Balmori-de la Pue...
3.93 · Institute of Evolutionary Bi...
3rd Helmut Breunig
4th Alfonso Balmori

Abstract

In the last two decades, the deployment of phone masts around the world has taken place and, for many years, there has been a discussion in the scientific community about the possible environmental impact from mobile phone base stations. Trees have several advantages over animals as experimental subjects and the aim of this study was to verify whether there is a connection between unusual (generally unilateral) tree damage and radiofrequency exposure. To achieve this, a detailed long-term (2006-2015) field monitoring study was performed in the cities of Bamberg and Hallstadt (Germany). During monitoring, observations and photographic recordings of unusual or unexplainable tree damage were taken, alongside the measurement of electromagnetic radiation. In 2015 measurements of RF-EMF (Radiofrequency Electromagnetic Fields) were carried out. A polygon spanning both cities was chosen as the study site, where 144 measurements of the radiofrequency of electromagnetic fields were taken at a height of 1.5m in streets and parks at different locations. By interpolation of the 144 measurement points, we were able to compile an electromagnetic map of the power flux density in Bamberg and Hallstadt. We selected 60 damaged trees, in addition to 30 randomly selected trees and 30 trees in low radiation areas (n=120) in this polygon. The measurements of all trees revealed significant differences between the damaged side facing a phone mast and the opposite side, as well as differences between the exposed side of damaged trees and all other groups of trees in both sides. Thus, we found that side differences in measured values of power flux density corresponded to side differences in damage. The 30 selected trees in low radiation areas (no visual contact to any phone mast and power flux density under 50μW/m(2)) showed no damage. Statistical analysis demonstrated that electromagnetic radiation from mobile phone masts is harmful for trees. These results are consistent with the fact that damage afflicted on trees by mobile phone towers usually start on one side, extending to the whole tree over time. http://kompetenzinitiative.net/KIT/KIT/baeume-in-bamberg/ http://kompetenzinitiative.net/KIT/wp-content/uploads/2016/09/Trees-in-Bamberg-and-Hallstadt-Documentation-2006-2016.pdf https://groups.google.com/forum/#!topic/mobilfunk_newsletter/5r37cJ-EqPI



International Journal of Forestry Research
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Abstract
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Research Article

Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings: Preliminary Observations

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Received 21 June 2009; Revised 31 October 2009; Accepted 17 February 2010

Academic Editor: Terry L. Sharik

Abstract

Numerous incidents of aspen decline have been recorded in North America over the past half century, and incidents of very rapid mortality of aspen clones have been observed in Colorado since 2004. The radio frequency (RF) environment of the earth has undergone major changes in the past two centuries due to the development and use of electricity in power and communications applications, and the anthropogenic RF background continues to increase in intensity and complexity. This study suggests that the RF background may have strong adverse effects on growth rate and fall anthocyanin production in aspen, and may be an underlying factor in aspen decline.

1. Introduction

Incidents of aspen decline in North America have been observed since the mid-20th Century [1–3]. Stands at the limits of aspen's lower elevation range, on sites with poor drainage, with limited water [4] or nutrient supply [5], are more susceptible to decline. Stand age and clonal differences are also factors in susceptibility to decline [6]. Factors initiating decline include: defoliation by insects, damage caused by wildlife, severe drought, and extreme weather incidents [7]. Damage caused by these factors can diminish the vigor of affected clones and make them vulnerable to opportunistic fungal pathogens and insects [8]. The concept of forest decline has been used to describe the interaction of these various factors; however, the underlying causes of aspen decline are not well understood [9]. Since 2004, incidents of very rapid aspen clone mortality have been seen in Colorado [10]. Because the electromagnetic (EM) environment of the earth has changed radically in the past two centuries, this study investigates the possibility that anthropogenic changes in this environment, particularly in the radio frequency (RF) spectrum, are adversely affecting growth and health of aspen populations, making them vulnerable to decline.

Electromagnetic energy from the sun is essential for life on earth. Plants rely on inputs of EM energy for photosynthesis and for regulation of periodic functions (flowering, shoot and root growth, respiration, and dormancy). A plant's response to EM energy is dependant on frequency, timing, and intensity of the signal. The source of the EM input, however, makes no difference. Timing of plant processes is an important mechanism for plant protection and efficient functioning in changing day/night and seasonal environmental conditions [11]. Although photosynthesis requires fairly strong energy input in the blue and red visual frequencies (full sun/shade) [12], photoperiodic responses in plants are typically triggered by energy inputs in the red and far-red frequencies that are in the range of 10^{-4} times the energy required for photosynthesis, and even a brief flash of light during a plant's subjective night can be enough to trigger a short night response, strongly affecting plant behavior and morphology [13]. The radio frequencies, lower than 300 gigahertz, are below visual and infrared frequencies in the electromagnetic spectrum. The earth's natural RF environment has a complex periodicity that has been more or less the same within the lifespan of modern tree taxa. Before 1800, the major components of this environment were broadband radio noise from space (galactic noise), from lightning (atmospheric noise), and a smaller RF component from the sun [14]. Because of the periodic nature of the naturally occurring RF background, plants may have evolved to use those environmental signals, as well as visible light, to regulate periodic functions, and therefore they may be sensitive to anthropogenic RF input. The intensity of the human-generated RF environment has increased gradually since about 1800. This background of RF pollution is now many times stronger than the naturally occurring RF environment. From the perspective of evolutionary time, the change can be considered sudden and dramatic [14, 15].

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Current Chemical Biology

Electromagnetic Fields Act Similarly in Plants as in Animals: Probable Activation of Calcium Channels via Their Voltage Sensor

Current Chemical Biology, **10**(1): 74-82.

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Abstract

It has been shown that low intensity microwave/lower frequency electromagnetic fields (EMFs) act in animals via activation of voltage-gated calcium channels (VGCCs) in the plasma membrane, producing excessive intracellular calcium $[Ca^{2+}]i$, with excessive $[Ca^{2+}]i$ leading to both pathophysiological and also in some cases therapeutic effects. The pathophysiological effects are produced largely through excessive $[Ca^{2+}]i$ signaling including excessive nitric oxide (NO), superoxide, peroxynitrite, free radical formation and consequent oxidative stress. The activation of the VGCCs is thought to be produced via EMF impact on the VGCC voltage sensor, with the physical properties of that voltage sensor predicting that it is extraordinarily sensitive to these EMFs. It is shown here that the action of EMFs in terrestrial, multicellular (embryophyte) plants is probably similar to the action in animals in most but not all respects, with calcium channel activation in the plasma membrane leading to excessive $[Ca^{2+}]i$, leading in turn to most if not all of the biological effects. A number of studies in plants are briefly reviewed which are consistent with and supportive of such a mechanism. Plant channels most plausibly to be involved, are the so-called two pore channels (TPCs), which have a voltage sensor similar to those found in the animal VGCCs.

Format: Abstract

J Plant Physiol. 2014 Sep 15;171(15):1436-43. doi: 10.1016/j.jplph.2014.06.013. Epub

Influence of microwave frequency electromagnetic radiation on terpene emission and content in aromatic plants.

Soran ML[1], Stan M[1], Niinemets Ü[2], Copolovici L[3].

Author information

Abstract

Influence of environmental stress factors on both crop and wild plants of nutritional value is an important research topic. The past research has focused on rising temperatures, drought, soil salinity and toxicity, but the potential effects of increased environmental contamination by human-generated electromagnetic radiation on plants have little been studied. Here we studied the influence of microwave irradiation at bands corresponding to wireless router (WLAN) and mobile devices (GSM) on leaf anatomy, essential oil content and volatile emissions in Petroselinum crispum, Apium graveolens and Anethum graveolens. Microwave irradiation resulted in thinner cell walls, smaller chloroplasts and mitochondria, and enhanced emissions of volatile compounds, in particular, monoterpenes and green leaf volatiles (GLV). These effects were stronger for WLAN-frequency microwaves. Essential oil content was enhanced by GSM-frequency microwaves, but the effect of WLAN-frequency microwaves was inhibitory. There was a direct relationship between microwave-induced structural and chemical modifications of the three plant species studied. These data collectively demonstrate that human-generated microwave pollution can potentially constitute a stress to the plants.

KEYWORDS: Abiotic stress; Aromatic plants; Essential oils; Microwave; Volatile organic compounds

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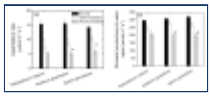
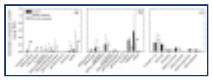
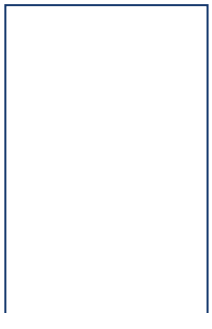

Format: Abstract

Plant Signal Behav. 2014;9(3):e28590. Epub 2014 Mar 26.

Nanometer-scale elongation rate fluctuations in the Myriophyllum aquaticum (Parrot feather) stem were altered by radio-frequency electromagnetic radiation.

Senavirathna MD[1], Asaeda T[1], Thilakarathne BL[1], Kadono H[1].

Author information

Abstract

The emission of radio-frequency electromagnetic radiation (EMR) by various wireless communication base stations has increased in recent years. While there is wide concern about the effects of EMR on humans and animals, the influence of EMR on plants is not well understood. In this study, we investigated the effect of EMR on the growth dynamics of Myriophyllum aquaticum (Parrot feather) by measuring the nanometric elongation rate fluctuation (NERF) using a statistical interferometry technique. Plants were exposed to 2 GHz EMR at a maximum of 1.42 Wm(-2) for 1 h. After continuous exposure to EMR, M. aquaticum plants exhibited a statistically significant 51 ± 16% reduction in NERF standard deviation. Temperature observations revealed that EMR exposure did not cause dielectric heating of the plants. Therefore, the reduced NERF was due to a non-thermal effect caused by EMR exposure. The alteration in NERF continued for at least 2.5 h after EMR exposure and no significant recovery was found in post-EMR NERF during the experimental period.

KEYWORDS: electromagnetic radiation; growth dynamics; non-thermal; plant stress; statistical interferometry; wireless communication

PMID: 24670369 PMCID: PMC4091600

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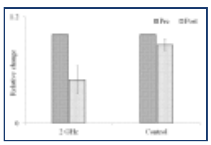
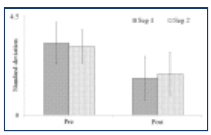
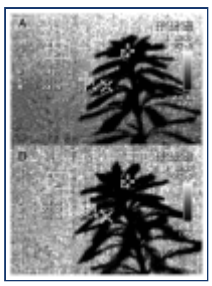
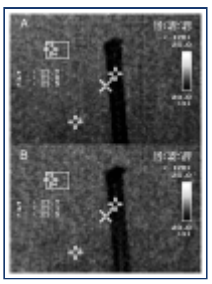


Publication Types, MeSH Terms

Bioelectromagnetics. 2015 Feb;36(2):87-95. doi: 10.1002/BEM.21890. Epub 2015 Jan 21.

Reduced growth of soybean seedlings after exposure to weak microwave radiation from GSM 900 mobile phone and base station.

Halgamuge MN[1], Yak SK, Eberhardt JL.

Author information

Abstract

The aim of this work was to study possible effects of environmental **radiation** pollution on plants. The association between cellular telephone (short duration, higher amplitude) and **base station** (long duration, very low amplitude) **radiation exposure** and the **growth** rate of **soybean** (Glycine max) **seedlings** was investigated. **Soybean seedlings**, pre-grown for 4 days, were exposed in a gigahertz transverse electromagnetic cell for 2 h to global system for **mobile** communication (**GSM**) **mobile phone** pulsed **radiation** or continuous wave (CW) **radiation** at **900** MHz with amplitudes of 5.7 and 41 V m(-1) , and outgrowth was studied one week **after exposure**. The **exposure** to higher amplitude (41 V m(-1)) **GSM radiation** resulted in diminished outgrowth of the epicotyl. The **exposure** to lower amplitude (5.7 V m(-1)) **GSM radiation** did not influence outgrowth of epicotyl, hypocotyls, or roots. The **exposure** to higher amplitude CW **radiation** resulted in **reduced** outgrowth of the roots whereas lower CW **exposure** resulted in a **reduced** outgrowth of the hypocotyl. **Soybean seedlings** were also exposed for 5 days to an extremely low level of **radiation** (**GSM 900** MHz, 0.56 V m(-1)) and outgrowth was studied 2 days later. **Growth** of epicotyl and hypocotyl was found to be **reduced**, whereas the outgrowth of roots was stimulated. Our findings indicate that the observed effects were significantly dependent on field strength as well as amplitude modulation of the applied field.

KEYWORDS: **base station**; **mobile** phones; radiofrequency electromagnetic fields; **soybean** seedling **growth**

PMID: 25644316 DOI: 10.1002/BEM.21890

[PubMed - indexed for MEDLINE]

Extremely Low-Frequency Magnetic Fields Induce Developmental Toxicity and Apoptosis in Zebrafish (*Danio rerio*) Embryos

Biological Trace Element Research
December 2014, Volume 162, Issue 1, pp 324–332

Authors **Authors and affiliations**

Ying Li, Xingfa Liu, Keran Liu, Wei Miao, Cheng Zhou, Yang Li, Hongjuan Wu

Article

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Abstract

Extremely low-frequency (ELF) magnetic field (MF), as a widespread ecological factor, has an influence on all living beings. In the present study, biological effects of ELF-MF on the development of zebrafish (*Danio rerio*) embryos were investigated. Fertilized embryos were divided into seven groups as control, sham, and five experimental groups. Embryos of experimental groups were continuously exposed to 50-Hz sinusoidal MF with intensities of 30, 100, 200, 400, and 800 μT for 96 h. The sham group was treated as the experimental groups, but without any ELF-MF exposure. The control group was not subjected to anything. The results showed that ELF-MF exposure caused delayed hatching and decreased heart rate at the early developmental stages of zebrafish embryos, whereas no significant differences in embryo mortality and abnormality were observed. Moreover, acridine orange staining assays showed notable signals of apoptosis mainly in the ventral fin and spinal column. The transcription of apoptosis-related genes (*caspase-3*, *caspase-9*) was significantly upregulated in ELF-MF-exposed embryos. In conclusion, the overall results demonstrated that ELF-MF exposure has detrimental effects on the embryonic development of zebrafish by affecting the hatching, decreasing the heart rate, and inducing apoptosis, although such effects were not mortal threat. The results also indicate that zebrafish embryos can serve as a reliable model to investigate the biological effect of ELF-MF.

Keywords

Zebrafish embryo ELF-MF Developmental toxicity Apoptosis

References

Electromagnetic Biology and Medicine, 24: 109–119, 2005

ISSN 1536-8378 print
DOI: 10.1080/15368370500205472

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Possible Effects of Electromagnetic Fields from Phone Masts on a Population of White Stork (*Ciconia ciconia*)

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Monitoring of a white stork population in Valladolid (Spain) in the vicinity of Cellular Phone Base Stations was carried out, with the objective of detecting possible effects. The total productivity, in the nests located within 200 meters of antennae, was 0.86 ± 0.16*. For those located further than 300 m, the result was practically doubled, with an average of* 1.6 ± 0.14*. Very significant differences among the total productivity were found (*$U = 240$; $p = 0.001$*, Mann-Whitney test). In partial productivity, an average of* 1.44 ± 0.16 *was obtained for the first group (within 200 m of antennae) and of* 1.65 ± 0.13 *for the second (further than 300 m of antennae), respectively. The difference between both groups of nests in this case were not statistically significant (*$U = 216$; $P = 0.26$*, Mann-Whitney Test U). Twelve nests (40%) located within than 200 m of antennae never had chicks, while only one (3.3%) located further than 300 m had no chicks. The electric field intensity was higher on nests within 200 m (*2.36 ± 0.82 *V/m) than on nests further than 300 m (*0.53 ± 0.82 *V/m). Interesting behavioral observations of the white stork nesting sites located within 100 m of one or several cellsite antennae were carried out. These results are compatible with the possibility that microwaves are interfering with the reproduction of white storks and would corroborate the results of laboratory research by other authors.*

Keywords Cellsites; Cellular phone masts; *Ciconia ciconia*; Electromagnetic fields; Microwaves; Nonthermal effects; Reproduction; White stork.

Introduction

Most of the attention on the possible biological effects of electromagnetic fields (EMF) has been focused on human health. People frequently use wildlife as biological indicators to detect the alterations in the ecosystems and in an urban

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Format: Abstract

Full text links

J R Soc Interface. 2014 Aug 6;11(97):20140451. doi: 10.1098/rsif.2014.0451.

Magnetic orientation of garden warblers (Sylvia borin) under 1.4 MHz radiofrequency magnetic field.

Kavokin K[1], Chernetsov N[2], Pakhomov A[3], Bojarinova J[4], Kobylkov D[2], Namozov B[5].

Author information

Abstract

We report on the experiments on orientation of a migratory songbird, the garden warbler (Sylvia borin), during the autumn migration period on the Courish Spit, Eastern Baltics. Birds in experimental cages, deprived of visual information, showed the seasonally appropriate direction of intended flight with respect to the magnetic meridian. **Weak** radiofrequency (RF) magnetic field (190 nT at 1.4 MHz) disrupted this orientation ability. These results may be considered as an independent replication of earlier experiments, performed by the group of R. and W. Wiltschko with European robins (Erithacus rubecula). Confirmed outstanding sensitivity of the birds' magnetic compass to RF fields in the lower megahertz range demands for a revision of one of the mainstream theories of magnetoreception, the radical-pair model of birds' magnetic compass.

KEYWORDS: magnetoreception; orientation; radical-pair model; radiofrequency fields

PMID: 24942848 PMCID: PMC4208380 DOI: 10.1098/rsif.2014.0451

[PubMed - indexed for MEDLINE] **Free PMC Article**

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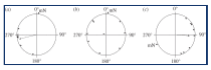

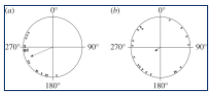

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Tree damages in the vicinity of mobile phone base stations

Cornelia Waldmann-Selsam and Horst Eger

Translation of the german article: Waldmann-Selsam, C., Eger, H. (2013):
Baumschäden im Umkreis von Mobilfunksendeanlagen, umwelt-medizin-gesellschaft, 26: 198-208.

Abstract: Since 2005, on the occasion of medical examinations of sick residents living near mobile phone base stations, changes in nearby trees (crown, leaves, trunk, branches, growth) were observed at the same time as clinical symptoms in humans occurred. Both deciduous and coniferous trees as well as shrub species were affected. The assessment of tree diseases is neither impeded by psychological impacts nor by change of location.
Impacts of radiofrequency electromagnetic fields (RF-EMF) from radar, radio and TV on plant life have been scientifically demonstrated over the past 80 years. Since 2005, the influence of modulated RF-EMF - that are used in mobile phone telephony - has been investigated in lab experiments. Several research groups reported about the impacts on germination, growth and cell metabolism. Only a few scientific papers have been published to date on research concerning the health conditions of trees in the vicinity of mobile phone base stations. These papers are indicating harmful impacts.
For this reason, between 2007 and 2013, the status of trees standing in the neighbourhood of 620 mobile phone base stations was documented. In the radio shadow of buildings or that one of other trees, the trees stayed healthy. However, within the radiation field, damages were observed on exposed trees. Additionally, unilateral crown damage, beginning on the side facing the antenna, strongly indicates a causal relationship with RF-EMF. In the following, examples of crown damages and of premature colouring of leaves are presented. The authors believe, that scientific research is urgently needed to examine these observations.

Keywords: *Mobile phone base station, radiofrequency electromagnetic fields (RF-EMF), tree damage*

Introduction

On the occasion of medical examinations of sick residents living near mobile phone base stations, it was often surprising, from 2005, that trees fell ill in the same surroundings simultaneously with humans (WALDMANN-SELSAM 2007).
During a workshop of the German Federal Office for Radiation Protection (BfS) on “Health effects of electromagnetic fields from mobile phone telephony - medical reports” on 2nd of .August 2006 not only six physicians presented exemplary diseases of people exposed to RF-EMF, but also the physicist and electrical engineer Dr.-Ing. V. Schorpp demonstrated damage patterns which indicated a causal relationship between tree damages and chronic RF-EMF exposure (BFS 2006, SCHORPP 2006; recent summary of his findings: 2011).
From 2004, Municipal gardeners in the Netherlands documented rapidly increasing, new and unexplainable patterns of damage. A contribution of RF-EMF was discussed (BOOMAANTASTINGEN 2013). As it became apparent that especially after UMTS starting tree damages increased with high speed at all the mobile phone base stations visited, affected trees have been documented then too.
In November 2007 the BfS refused scientific investigations: “As to potential effects of RF-EMF on plants there are no clear indications from scientists up to now. That's why I do not attach priority to this question either.” (DEHOS 2007).
The reference book “Dendrology and Tree care” (“Baumkunde und Baumpflege” in German) of Dipl. hort. Dr. phil. nat. Aloys Bernatzky from 1994 and further publications out of eight decades verify however, that the statement of the BfS is not supported by the actual state of scientific documentation (BERNATZKY 1994, WALDMANN-SELSAM 2010).